Visualizing Sight Experience
Lillianna Marie Baczeski

Background

Had you been an experimental eye-tracking subject of Russian psychologist Alfred Yarbus in the 1950s, your eyelids would have been pried back and glued down with plaster adhesive, while a suction "cap" fitted with a tiny mirror was affixed tightly to your cornea.[i] The mirror would have reflected a light beam onto a piece of photosensitive paper, and a "map" would have been produced from the movements your eyes made while gazing at Ilya Repin's 1884 painting *The Unexpected Visitor*. Yarbus is well known for discovering that human eyes return to, and rest on, "landmarks" in an image -- like faces, or eyes within a face – in between dashing saccades (Figure 1-3).

Figures 1, 2, and 3: Early examples of eye tracking by Alfred Yarbus.

Yarbus's pioneering work built on a long history of inquiry into how eyes function, traced back to at least the 4th-century BCE writings of Aristotle.[ii] Today, researchers in psychology, neuroscience, and vision science still heavily cite Yarbus's work. Contemporary eye-tracking technology is far less invasive than Yarbus's and works by reflecting near-invisible infrared light off the human eye directly, eliminating the need for caps, glues, or mirrors. With this system, movements of the pupil are digitally encoded, pinpointing the exact x- and y-pixels to which the eyes are attending over time.[iii] In isolation, and in conjunction with other methods of data collection (such as EEG and fMRI), eye tracking technology is used by scientists to explore and make measurable claims to advance knowledge in pursuit of the question: How do humans see? Though I am not a scientist, my investigations originate from the same question. In my current work, I approach this question with the tools of a scientist, but with the capacity of an artist.

Purpose

How *do* humans see? The photographic community is perpetually seeking out new imaging technologies. New methods of image-making advance our understanding of the world, and each other. Despite this gravitation, relatively little artistic research has been conducted using contemporary eye-tracking technology. I became interested in the possibility of using computer-based eye-tracking as an artistic tool. Nestled in, and responding to, the complex histories of photography, video, and eye movement research, my work challenges viewers to contemplate how the presentation of visual information through a new form redefines understandings of sight experience. My project also set out to create the first moving-image and photographic-based artistic works produced using eye-tracking technology.

Methods

Using an infrared eye tracker at The Ohio State University's Vision and Cognitive Neuroscience Lab, I presented myself and other viewers with photographic images for a period of ten seconds. Some of the images were of my own making, and others were appropriated from the Internet. The color, composition, subject matter, and density of visual information vary across the images. My selections of portraits, landscapes, and abstract photographs were motivated by their aesthetic qualities.

While viewing the images in the eye tracker, a computer recorded the x- and y-pixel locations, and timestamp as fast as processing power allowed (Figures 4 and 5). From this data, I used the visual angle calculation and extracted the portions of the image on which the eyes were focused at each given millisecond (Figure 6 and 7).

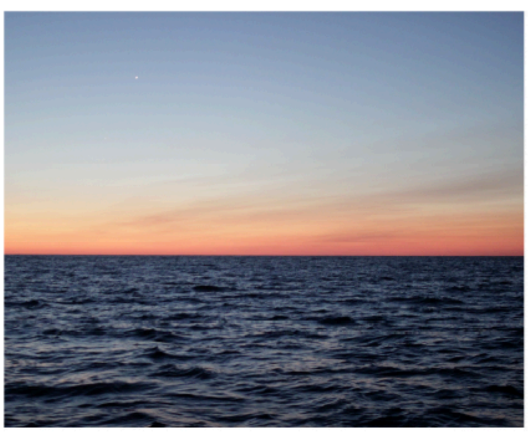

Figure 4: A full image on the eye-tracking computer screen is 1280 pixels by 1024 pixels.

Time	X-Pixel Location	Y-Pixel Location
1.50E-03	5.77E+01	1.39E+02
1.83E-03	5.77E+01	1.39E+02
1.98E-03	5.68E+01	1.39E+02
2.89E-03	5.68E+01	1.39E+02
4.11E-03	5.75E+01	1.42E+02
5.10E-03	5.75E+01	1.42E+02
6.12E-03	5.67E+01	1.41E+02
7.06E-03	5.67E+01	1.41E+02
8.07E-03	5.65E+01	1.41E+02
9.05E-03	5.62E+01	1.41E+02
1.00E-02	5.56E+01	1.41E+02
1.10E-02	5.57E+01	1.41E+02
1.19E-02	5.57E+01	1.41E+02
1.30E-02	5.54E+01	1.42E+02
1.42E-02	5.51E+01	1.42E+02
1.51E-02	5.51E+01	1.42E+02
1.61E-02	5.51E+01	1.43E+02

Figure 5: A sample data set shows time, x- and y-pixel location of pupil.

Figure 6: Five seconds of time

Using every data point collected, I created approximately 10,000 frames per image to map the original sight path. A custom-designed Python computer code, developed specifically for my project, facilitated this image extraction from the sorted data. These 10,000 frames were then fed back into video-editing software to reanimate the path of the eyes (Figures 8). This process was repeated for each image. The end result was a video work that animates the thousands of frames. Viewers ultimately watched the path another person's eyes took while looking at the initial photographic images in the lab.

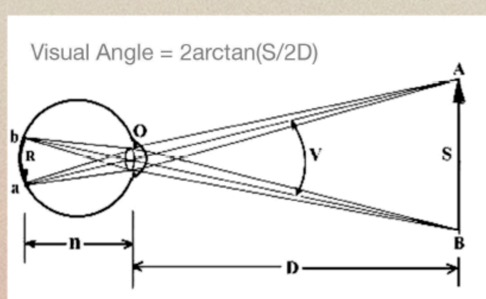

Figure 7: The visual angle calculation determines the portion of an image in focus at a given distance from screen.

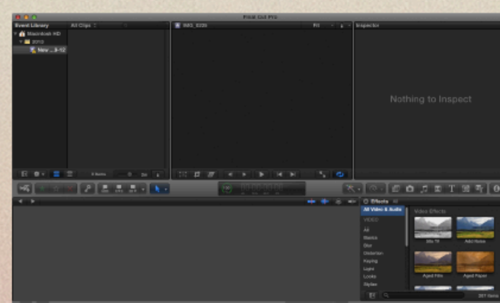

Figure 8: A view of Final Cut Pro, the editing software used to animate the extracted image frames.

Findings

While a scientist might be concerned with recognizing patterns and correlations across viewers' sight paths, this is where, as an artist, I diverge from scientific inquiry. My interest is in the aesthetic product I created when re-animating the various paths eyes took.

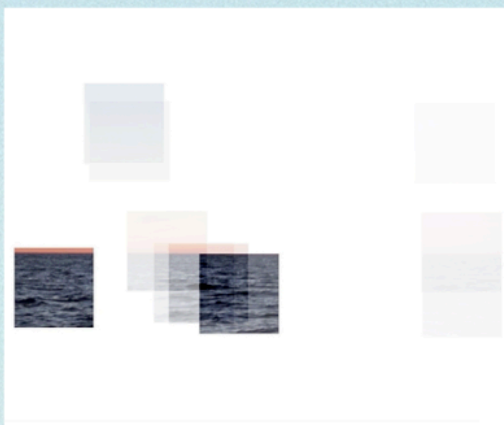

Figure 9: A still representation of the resulting moving image work.

I asked myself: *How can I use this data as an artist to present new modes of understanding sight through a visual product?* Recording as much data as the computer's processing time allowed, led to an interesting problem; the totality of data fed back into an editing program resulted in a video that was much longer than the original ten seconds a participant viewed the image while eye-tracking. This discrepancy happens because video-editing software cannot subdivide time into units as small as the eye-tracking software can. Here, I had a decision to make:

1. I can delete some of the data points collected.
2. I can sample every *n*th data point collected.
3. I can use all the data, and then speed up the resulting video.
4. I can allow the resulting video to be longer than the original ten second viewing time.

While contemplating these questions of how to represent the visual information I collected, I began to make small models to help explain to others what I was doing. This led to three additional new art-forms based on the same information:

1. A series of flip-books that translate the sight path into a timescale determined by the hand. (The eyes become the hand.)

2. An installation where each data point equated to a photograph in space. As viewers walk from the front of the room to the back of the room, they walk the path of the eye. (The eyes become the feet and body).

3. Framed photographs that represent only a few fragments of time collected.

Figure 11: A flipbook

Significance

It is important to note that I am not making universal claims about sight, and I am not "doing science." As an artist, I am paying attention to the way that the eyes of an individual move over particular images, and re-presenting that experience to viewers through different artistic forms.

The criteria of success for an artist differ from that of a scientist, and to view my work it is vital for the two types of research not to be conflated.

While it may initially seem strange for an artist to employ the tools of a scientist, photography was developed in the mid 1800s simultaneously under the auspices of science and art, making my cross-pollination another data point in a complicated history.[iv] Photography has long defied a singular categorization, and as Roland Barthes famously suggested, "We might say Photography is unclassifiable."[v] Categorizations aside, today, photographic practice and photographic imagery comfortably inhabit the art realm, the scientific world, and the personal lives of billions of people on our planet. Since my work begins with the production and fragmentation of thousands of photographic images, it is situated in this nebulous, rapidly expanding history in relation to other artists I greatly admire, like Penelope Umbrico, Roni Horn, and Felix Gonzalez-Torres, who have also investigated continua, repetition, and seriality. My previous graduate work – including the video *Yorkville Before Elaine's & Other Stories* funded by Coca Cola's Critical Difference for Women Grant in 2014, and the installation *High-Sky* funded by the Barbara and Sheldon Pinchuk Arts-Community Outreach Grant in 2014 – explore similar ideas.

In addition to photographic histories, this work finds relation to video histories as well. In the 1970s, early video artists gained access to technologies for the production and dissemination of media that had previously been controlled by large corporations with primarily economic incentives.[vi] These early video artists started creating works that "fed back" into previously closed-circuit corporate dialogues, disrupting and redefining the positions that viewers of video and television had to the media they were consuming. Likewise, using contemporary technologies, this project will probe my own viewers to consider their positions, and specifically the physiological movements of their eyes in relation to their visual perceptions, on the other side of the screen.

This project has led to several "firsts:" The creation of the first moving image work, first flipbook series, and first installation that all use eye-tracking technology. It has also led to the production of several photographic works that will travel to exhibition shows across the United States in the coming years.

This project has also allowed me to develop a new mode of art-making: using eye-tracking technology and translating the resulting data through a series of computer codes to create a moving-image work. Currently, I am building a web-based application that will make public the code and methods I developed for this project. To do this, the code must be rewritten to accommodate low-cost eye-tracking systems that can be accessed through the built-in cameras on laptops and smart phones. Once the application is re-coded, it will allow others to use only their eyes to make their own moving-image works. While I am excited to offer free public access to this tool, I am particularly thrilled about sharing it with disabled persons who are only able to move their eyes.

Acknowledgements

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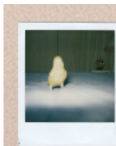

Figure 12:
Cello

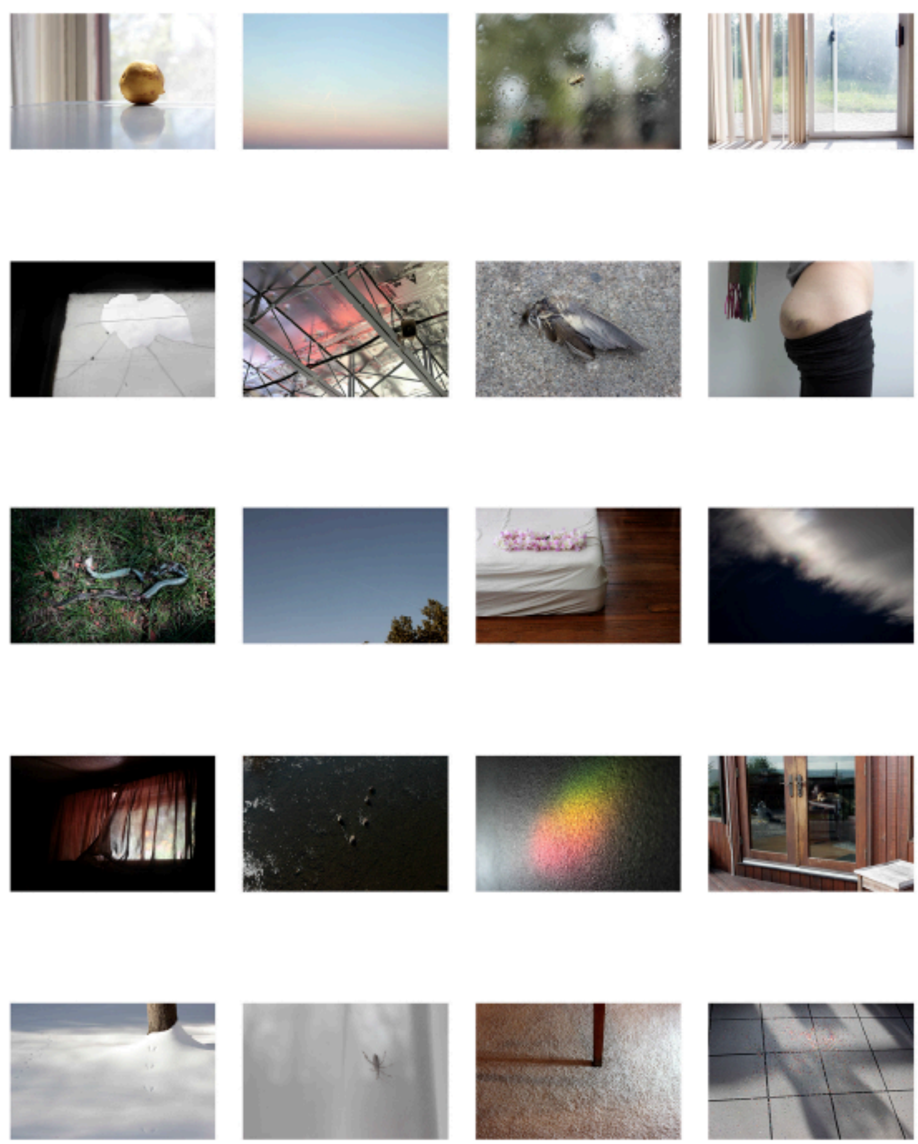

Figure 13: More of my images used in the tracker.

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